International Journal of Environment, Ecology,
Family and Urban Studies (IJEEFUS)
ISSN (P): 2250-0065; ISSN (E): 2321-0109
Vol. 8, Issue 3, Jun 2018, 11-24

HOW WILL CHANDIGARH GROW SPATIALLY IN FUTURE? MODELING IT'S PERI-URBAN SETTLEMENTS WITH FUTURE PLANNING PERSPECTIVE

SOUROVEE DUTTA[1] & MADHUMITA ROY[2]

[1]*Assistant Professor, School of Architecture & Landscape Design, Shri Mata Vaishno Devi University Kakryal, Katra, Jammu & Kashmir, India*

[2]*Professor & Former HOD, Department of Architecture, Jadavpur University, Kolkata, India*

ABSTRACT

This paper attempts to formulate a futuristic model for delineation of peri-urban interface for Chandigarh, India; on the basis of specific planning parameters evolved from background research and historical dataset. These parameters contribute towards the measurement of their degree of association and accordingly frame probabilistic statistical model to delineate peri-urban realm around cities. The paper questions the existing criteria of Rural-Urban Classification defined by the Census of India and describes its role in non-recognition of peri-urban areas in the settlement hierarchy and creating disparity in the process of development. The paper has elaborated the experiment in the unique context of Chandigarh, where the peri-urbanization has spread in three adjoining states. A total of 16 peripheral towns fall within the 16k.m. radius peripheral boundary of Chandigarh, which is taken into consideration for the proposed model. Three different statistical methods – Linear & Quadratic Regression Model and Matrix method have been applied, using analytical software MINITAB; to evaluate that how the selected parameter varies with the location of a peripheral settlement and through which equation, they can be defined better. Comparing the outputs from various methods applied, the paper concludes with a hierarchy of settlement structure using a common planning parameter.

KEYWORDS: Futuristic Model, Hierarchy of Settlement, Peri-Urban Interface, Planning Parameters & Rural-Urban Classification

Received: Mar 30, 2018; **Accepted:** Apr 19, 2018; **Published:** May 07, 2018; **Paper Id.:** IJEEFUSJUN20182

Original Article

INTRODUCTION

The Peri-Urban Growth Dynamics at Chandigarh

Traditionally across the world, settlements are classified as 'Urban' and 'Rural', where the definition is predominantly based on population, density, and occupational structure. However, this conventional method of classification has a tremendous drawback in addressing the Peri-Urban area, lying in-between. Urban growth dynamics at peri-urban interfaces and their interaction with multiple variables are intrinsically complex and hence are a potential field of contemporary research in urban planning (Shaw, 2005). The peri-urban area is found as the most dynamic realm in the urban-rural system, which is subjected to continuous transformation within a span of time, thus difficult to delineate this ever changing area. In the current practice in India, the major drawback lies in the definition & delineation of 'Rural-Urban', for which the Master Plan preparation process for cities becomes ineffective, even the fund estimation & distribution of urban development projects appears inappropriate. Due to Census definition in a dichotomous fashion, the peripheral areas are never taken into

consideration while preparing Master Plan. The proposed methodology to categorize settlements into urban-peri-urban-rural like structure, to delineate the peri-urban areas and to modify the Census definition with a new dimension; may be applied for all the settlements included in Census of the country in future, which may help in reducing issues in urban planning, policy-making and governance level and as a whole distribution of funds for urban development and projects across settlements can be ensured with a sense of justice and fairness (Bhagat, 2005). Thus it is felt to experiment with a regional planning approach, considering the city core along with its future peri-urban areas, delineate them through proposed variables and mathematical model.

This paper, a part of the Ph.D. Research began with the quest of understanding various transformations happening in these peripheral towns around the selected case city in the span of last decade, the factors behind such transformations and their implications on the parent city, Chandigarh. However, it is felt that formation of settlement clusters/typologies and their delineation through a statutory Master Plan and relevant planning policy, to govern the unregulated growth at peri-urban realm is the need of the hour (Saxena, et al, 2015). Such detailed study and analysis have created a strong base to identify the determinants governing the peripheral growth. Several variables have also been identified from previous literature studies, where the nature of transformation found similar. Such variables are considered here to frame mathematical model for the purpose of categorization and delineation of peri-urban areas. Eleven sets of variables / parameters under four major aspects along with their several sub-sets / indicators are selected based on the studies carried out by several researchers for different cities and towns of India and abroad (Budiyantini, et al, 2016; Census of India, 2001-11; Firoz, et al, 2014; Goncalves, et al, 2017) as well as context-specific studies carried out by the author. The analysis of interrelations of two variables is shown here, whereas interrelation among other variables may be explored in future in a similar manner for further categorization of the Urban-Rural system. As a whole, this paper addresses the issue of peri-urban growth with a focus on the context of Chandigarh, analyses the interrelationship among various parameters responsible for the phenomenon of peri-urbanization, further leading towards categorization of city peripheral areas.

BACKGROUND OVERVIEW

Due to its dynamic nature, prediction in the field of spatial planning is difficult. Urban growth/sprawl are the most commonly discussed in today's spatial planning practices, especially for the developing countries like India. As urban growth is a continuous process, temporal in nature, it is being very difficult to measure it. Hence we observe inadequacy at every strata of urban systems. In this scenario, 'Urban Modeling' has emerged as a revolutionary thought, where the boundaries between traditional disciplines are blurring in response to the need for interdisciplinary cooperation (Batty, 1976). The field of urban modeling is concerned with designing, building and operating mathematical models for urban phenomena, specifically for cities and regions. Till date, conventionally various planning theories are being used to visualize the future cities and prepare their Master Plans. However, it has never been quantified/predicted. In such circumstances, Urban Modeling helps to predict, prescribe and invent the urban future. It overcomes the limitations of planning theory and demonstrates the potential of simulation (Batty, 1976). Models are simplifications of reality - theoretical abstractions that represent systems in such a way that essential features crucial to the theory and its application are identified and highlighted (Batty, 2009). In this context, Urban Modeling is evolved from mathematical equations are simulations of the way cities may grow, on the basis of historical datasets. The rationale for developing models of the urban system is strong in the fields of urban design and physical planning. The idea of designing a working model of the

city with the notion that future plans for the city can be simulated and evaluated on the computer is an appealing and immensely exciting concept (Batty, 1976). With this overview on Urban Modeling, this paper attempts to formulate a mathematical model for delineation of peri-urban interfaces.

DISCUSSIONS ON METHODOLOGY

Selection of Sample Settlements, Overview of Data Sources

As discussed earlier, the peripheral towns fall within the 16 k.m. radius peripheral boundary around Chandigarh have been taken into consideration to frame the proposed model. This includes 2 settlements at the immediate periphery of Chandigarh Municipal Corporation, 7 settlements in the adjoining state of Punjab and 4 settlements in another adjoining state of Haryana. 3 other settlements in the adjoining state of Himachal Pradesh also lies just adjacent to the 16 k.m. peripheral boundary of UT and contributes significantly in the peripheral transformations as per the previous study and analysis of the research. Hence, they are also considered for the proposed scenario. The entire dataset has been collected from both primary and secondary sources, includes household survey as well as data from various govt. departments and authorities of these 3 states along with Chandigarh, UT, as elaborated later (Chandigarh Administration, 2016). The data has been tabulated against each of the identified variables for these 16 selected peripheral towns. The collected data for the selected variables are put for statistical analysis, leading towards the futuristic model.

Method of Data Analysis

For the purpose of research, 2 parameters have been selected, considering significant contributor towards peripheral transformations. Three statistical methods have been adopted here to compare the output/results based on the experimental values (historical data / collected data) and finally to formulate the model for delineation of peri-urban interfaces.

Linear Regression Model

- Definition – Simple linear regression is a statistical method that allows us to summarize and study relationships between two continuous (quantitative) variables: One variable, denoted X, is regarded as the predictor, explanatory, or independent variable and the other variable, denoted Y, is regarded as the response, outcome, or dependent variable.
- Formula – A linear regression line has an equation of the form
- $Y = a + bX$ (1)

where X is the explanatory variable and Y is the dependent variable. The slope of the line is b, and a is the intercept (the value of Y, when X = 0).

- Interpretation of the formula – The most common method for fitting a regression line is the method of least-squares. This method calculates the best-fitting line for the observed data by minimizing the sum of the squares of the vertical deviations from each data point to the line (if a point lies on the fitted line exactly, then its vertical deviation is 0). Because the deviations are first squared, then summed, there are no cancellations between positive and negative values.
- Applicability of the model **–** The model is applicable when we want to establish a relationship between two

variables. We are now ready to summarize the four conditions that comprise "the simple linear regression model:

The mean of the response, $E(Y_i)$, at each value of the predictor, X_i, is a Linear function of the X_i.

The errors, ε_i, are Independent.

The errors, ε_i, at each value of the predictor, X_i, are Normally distributed.

The errors, ε_i, at each value of the predictor, X_i, have Equal variances (denoted σ^2).

- Interpretation of the model output – Regression analysis generates an equation to describe the statistical relationship between one or more predictor variables and the response variable. The ‘p-value’ for each term tests the null hypothesis that the coefficient is equal to zero (no effect). A low p-value (< 0.05) indicates that we can reject the null hypothesis. In other words, a predictor that has a low p-value is likely to be a meaningful addition to our model because changes in the predictor's value are related to changes in the response variable. Conversely, a larger (insignificant) p-value suggests that changes in the predictor are not associated with changes in the response.

Quadratic Regression Model

- Definition – A quadratic regression is a process of finding the equation of the parabola that best fits a set of data. As a result, we get an equation of the form:

$$Y=aX^2 + bX + c \tag{2}$$

where $a\neq0$. The best way to find this equation manually is by using the least squares method. That is, we need to find the values of a, b and c such that the squared vertical distance between each point (X_i, Y_i) and the quadratic curve $Y=Ax^2+bX+cY=Ax^2+bX+c$ is minimal.

- Interpretation of the formula – The interpretation of a quadratic equation is highly dependent on the context. One possible context which occurs commonly is when the minimum X value is zero or near zero and a negative value is impossible. In this situation, the intercept, c, represents the estimated value of Y when $X = 0$. The interpretation of the quadratic term, a, depends on whether the linear term, b, is positive or negative.
- Applicability of the model – This model is applicable when the data points are non-linear in nature.
- Interpretation of the model output –The model gives similar output like Simple Linear Regression.

Matrix Method

- Definition – A matrix formulation of the multiple regression models comes while in the multiple regression setting, because of the potentially large number of predictors, it is more efficient to use matrices to define the regression model and the subsequent analyses. Here, we review basic matrix algebra, as well as some of the more important multiple regression formulas in matrix form, which are relevant to this research. Considering the following simple linear regression function:

$$Y_i = \beta_0+\beta_1X_i+\epsilon_i, \text{ for } i=1, \ldots\ldots n \tag{3}$$

If we actually let $i = 1, \ldots n$, we see that we obtain n equations:

$Y_1 Y_2 \vdots Y_n = \beta_0+\beta_1 X_1+\epsilon_1 = \beta_0+\beta_1 X_2+\epsilon_2 = \beta_0+\beta_1 X_n+\epsilon_n$ (4)

As we can see, there is a pattern that emerges. By taking advantage of this pattern, we can instead formulate the above simple linear regression function in matrix notation:

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} 1 & x_1 \\ 1 & x_2 \\ \vdots & \vdots \\ 1 & x_n \end{bmatrix} \begin{bmatrix} \beta_0 \\ \beta_1 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{bmatrix}$$

$$Y = X\beta + \varepsilon$$

That is, instead of writing out then equations, using matrix notation, our simple linear regression function reduces to a short and simple statement:

$Y = X\beta + \epsilon$ (5)

where, X is an **n × 2** matrix, Y is an **n × 1** column vector, β is a **2 × 1** column vector, and ε is an **n × 1** column vector. The matrix X and vector β are multiplied together using the techniques of matrix multiplication and the vector Xβ is added to the vector ε using the techniques of matrix addition.

Formula

So, clearly the **least square normal equations** can be expressed in matrix form as

$$X^T X\hat{b} = X^T y$$

Therefore the regression coefficients can be estimated by

$$\hat{b} = \left(X^T X\right)^{-1} X^T y$$

So, the regression model can be written as

$\hat{y} = X\left(X^T X\right)^{-1} X^T y = Hy$, where $H = X\left(X^T X\right)^{-1} X^T$ is known as the 'hat' matrix, i.e. the matrix that converts observed values of y into vector of fitted values $\hat{y}$.

- *H* is symmetric, i.e $H = H^T$, so that $h_{ij} = h_{ji}$.
- *H* is idempotent, i.e. $H^2 = H^T H = H$.

- Interpretation of the formula – The interpretation of the formula is as similar as Simple Linear Regression.
- Applicability of the model – The application of this model is similar to Simple Linear Regression.
- Interpretation of the model output –The model gives similar output like Simple Linear Regression.

All the above stated statistical analysis is done over the relevant dataset of the research using **statistical analytical software, 'MINITAB, Version 17'.**

DATA COLLECTION AND STUDY

Physical Dimension of the Study Area

The study is conducted in the context of Chandigarh and its periphery. The study, survey and analysis of the periphery includes the emerging settlements within the 16 k.m. boundary of Chandigarh UT, and few other settlements in the state of Himachal Pradesh lies just adjacent to it and creates impact in the transformation of the peripheral area. The settlements are shown in the figure below (Figure 1).

Aspects / Dimensions, Variables and their Respective Indicators Selected for Deriving Futuristic Model for Peri-Urban Interface

To create peri-urban settlement typologies, an approach has been taken to determine the parameters / indicators, which contribute towards the measurement of the type/nature of ‘Urban Tendency’ or ‘Rural Tendency’ of the settlement. The similar cases of typology delineation by various studies, like PLUREL, ESPON, OECD in a European context is studied (OECD Regional Typology, 2011) and the parameters used for determining the settlement typology is explored. Apart from these literature reviews, certain other indicators are also added, which are found relevant specifically for the Indian context. In the broader way, the parameters found are classified into 4 major aspects/dimensions - Physical, Social, Economic, and Governance, under which the variables are determined. The variables are further measured by nos. of indicators as appropriate. All these indicators along with their sources are listed in the Table below (Table 1).

Identification of Quantifiable and Non-Quantifiable Indicators for Deriving Futuristic Model for Peri-Urban Interface

The indicators are further categorized in terms of method of quantification, if possible. Certain planning parameters are found non-quantifiable using currently available planning tools and a dataset of the context. This may be considered in future avenues of research, so that these indicators can be included in the process of classification of peri-urban realms. The selected indicators along with their source of data collection are mentioned in the table above (Table 1).

The Quantifiable Indicators and their Respective Values for Selected Peripheral Settlements within 16 k.m. Boundary of Chandigarh UT

The data has been collected for each of the selected indicators against each of the peripheral settlements and these values are graphically analyzed. It is observed that unlike the parameters – ‘population’, ‘population density’, ‘% of the male working population in non-agricultural activities’ etc.; which lacks in capturing the degree of urbanity of a settlement and not able to categorize them; some other planning parameters may define ‘Urban’ better and can create settlement hierarchy using their interrelation / equation among them. In this context, the parameters found most relevant, are ‘distance of the peripheral settlement from its nearest core urban area’, ‘ratio of built v/s open’, ‘area of non-agricultural land’, ‘area of open spaces / % of green cover’, ‘travel time from core to periphery’ etc.

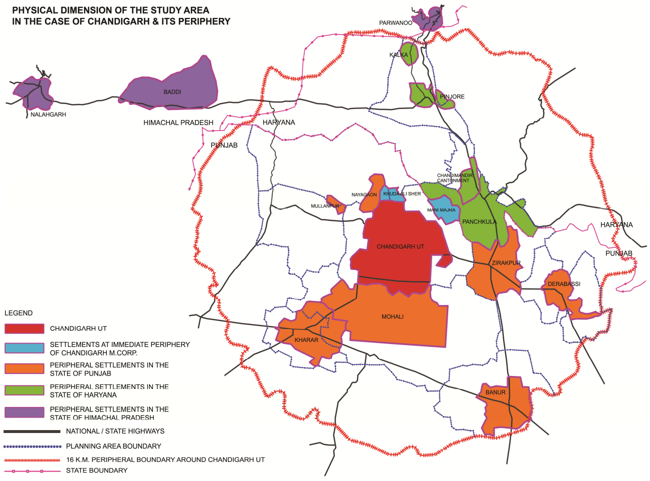

Figure 1: Physical Dimension of the Study Area (Source: Author, 2016)

Table 1: List of Aspects, Variables & Indicators for Deriving Peri-Urban Typology

Aspects	Variable	Indicators (I)	Source
Physical	***Spatial Planning***	% of Houses Located in Main Built-Up Area (HBUA)	*a
		Distance from the Nearest Core Urban Area (DCUA)[1]	*a
		Distance between Main BUA & Separate Area (DBMS)[1]	*a
		Contiguity of Houses - Avg. Distance between Houses (DBH)	*a
	Land-Use / Land Cover	Change in Area between 2001 and 2011 (%) (CA)[1]	*a
		Residential Land-Use Changes between 2001 and 2011 (%) (RLUC)[1]	*a
		Land Cover Variety - Ratio of Built v/s Open (RBO) (1:x)[1]	*a
		Area of agricultural land (%) (AL)[1]	*a
		Area of non-agricultural land (%) (NAL)[1]	*a
	Density	Housing Density (Residential Units / sq. k.m.) (HD)	*b
		Population Density (People per sq.k.m.) (PD) - 2011 Census[1]	*c
		Household Density (HHs per sq.k.m.) (HHD) - 2011 Census[1]	*d
	Natural Elements	Change (Increase / Decrease) in Green Cover between 2001 and 2011 (%) (CGC)	*a
		Change (Increase / Decrease) in Area / Length of Water Courses between 2001 and 2011 (%) (CWC)	*a
		% of Area Occupied by Green Elements / Green Covers (includes all kind of open spaces) (GC)[1]	*e
	Mobility / Accessibility	Car Dependency/1000 pop. (CD)	*a
		Travel Time in Public Transport to the Core Urban Area (min) (TTPC)[1]	*e
		Commuting - % of Total Pop. Commute to Core City for Work / Study / Other Purposes (TPC)[1]	*a
	Road Infrastructure (RI)	Black Road Length/1000 pop.	*a
		Ratio of Surfaced Road Length to Unsurfaced Road Length	
		Ratio of Asphalt Roads to the Total Area of Roads	*b
		Ratio of Paved Roads to the Total Area of Roads	
		Road Density/1000 pop.	*a
	Social / Civic Infrastructure (CI)	Nursery and Primary Schools[1]	*d

	Educational	Senior Secondary School[1]	
		College Campus[1]	*a
	Health Care	Hospital (500 / 200 / 100 bedded)[1]	*b
		Primary Health Centre / Poly-clinic[1]	*a
		Nursing home / Child Welfare[1]	
		Dispensary[1]	*d
	Socio-Cultural Facilities	Sports Facilities	*a
		Library and Community Hall[1]	*a
		Recreation Club[1]	*d
		Art & Cultural Centre[1]	*a
		Meditation & Spiritual Centre[1]	*d
	Other Civic Needs	Banks	*a
		Local Everyday Shops	*a
		Police Post[1]	*a
		Fire Station[1]	*a
	Communication and Information Facility (CIF)	Telephone Connections / Mobile Connections/1000 pop.	*a
		No. of Post Offices and Private Couriers	
	Physical & Housing Infrastructure (HI)	% of Houses Electrified	*a
	Housing	% of Pacca Houses[1]	
	Water Supply	Coverage of piped water supply connections[1]	*e
		Per capita supply of water[1]	
		Extent of metering of water connections[1]	
		Extent of non-revenue water (NRW)[1]	*d
		Continuity of water supply[1]	
		Cost recovery in water supply and sewerage services[1]	
	Sewage Management	Coverage of Toilets[1]	
		Coverage of sewerage network[1]	*a
		Adequacy of sewage treatment capacity[1]	
		Extent of Reuse and Recycling of Waste Water[1]	
	Solid Waste Management	Household level coverage of solid waste management services[1]	
		Efficiency of Collection of Municipal SW[1]	*d
		Extent of Segregation Of Municipal SW[1]	
		Extent of municipal solid waste recovered[1]	
		Extent of scientific disposal of municipal solid waste[1]	
		Cost Recovery in SWM Services[1]	
	Drainage	Coverage of Storm Water Drainage Network[1]	*a
Social	***Demography***	Sex Ratio (SR)	*d
		Dependency Ratio (DR)	*b
		Population (P) - 2011 Census[1]	*c
		Growth Rate of Population 2001-2011 (%) (GRP)[1]	*a
		Household Size (HHS) - 2011 Census[1]	*a
	Labour Force Characteristics	Main Workers, Marginal Workers (Male & Female) (MW & MRW)	*d
		Non Workers (Male & Female) (NW)	
	Live Stock (LS)	Concentration of Live Stock	*d
	Literacy (LT)	Percentage of Literates (Male, Female & Total)	*d
	Community Dimension / Social Cohesion	% of Joint Family Houses per 1000 pop. (JFH)	*e
		% of Multicommunal Agglomeration (MCA)[1]	*a
		% of Single / Nuclear Family Houses per 1000 pop. (SFH)	*e
Economic	***Sector-wise Employment***	Employment in Agricultural Sector, % of working pop. (Male, Female and Total) (EAS)[1]	*a, *e, *d, *b,

		Employment in Non-Agricultural / Manufacturing / Other Sector, % of working pop. (Male, Female and Total) (ENAS)[1]	*c
Governance		Present Administrative Body[1]	*a, *c

[a] Author's own research, [b.] [4], [c.] [5], [d.] [6], [e.] [7], [1] Quantifiable Indicator (QI).

ANALYSIS, RESULTS & DISCUSSIONS

The collected data from 16 peripheral towns against each of the variables are analyzed with the aim of formulating a mathematical model, based on the selected parameter. The presence of a peri-urban settlement is measured through 'distance of the town from the core city/core urban area' in k.m. The attempt has been made to find how the emergence of the peri-urban settlements is evolved with respect to any of the planning parameters. Such relationship may be established through the statistical analysis of the collected data. The preliminary observation of the collected data shows that with increasing distance of a peripheral settlement from the core city, the total area of open space increases and hence the total area of built space decreases. Considering these two variables (% of the total open space as dependent variable and distance from the core city as independent variable), statistical analysis is done to find whether they are interrelated and if so, then how.

Selection of Parameters

X - Distance from the Nearest Core Urban Area (in k.m.), Y - % of Area Occupied by All kinds of Open Spaces. Data of these two parameters are collected for all the selected 16 peripheral towns around the study area of Chandigarh.

Results from Experimental Values

X - Distance from the Nearest Core Urban Area (in k.m.), Y - % of Area Occupied by All kinds of Open Spaces. Data of these two parameters are collected for all the selected 16 peripheral towns around the study area of Chandigarh.

Applying Linear Regression Model, the equation for X & Y is established, the estimated values of Y and the related error values are analyzed, as shown in Table 2.

Table 2: Results of Linear Regression

X	Y	Y^ (Linear Model)	Error=Y-Y^
8	26	29.24	-3.24
6	20	26.86	-6.86
9.5	31	31.025	-0.025
13	36	35.19	0.81
16	48.5	38.76	9.74
6	21	26.86	-5.86
22	53	45.9	7.1
32	58	57.8	0.2
9	26	30.43	-4.43
12	34.5	34	0.5
25	55	49.47	5.53
29.5	56.6	54.825	1.775
14	42	36.38	5.62
46	67.4	74.46	-7.06
36	61	62.56	-1.56
36.5	61	63.155	-2.155
			0.085 (sum of the errors)

The linear regression equation is

Y = 19.72 + 1.190 X (6)

Here, Pearson correlation of Y and X = 0.948 & value of R-SQ = 89.9%. As shown in Figure 2, the value of Pearson Correlation is positive, indicating the proportional relationship between X & Y. The model summary also shows that value of R-sq is 89.9%, which means such percentage of variation of historical data is explained by the model. The total value of errors due to the difference between collected values of Y & estimated values of Y is minimal, i.e. 0.085.

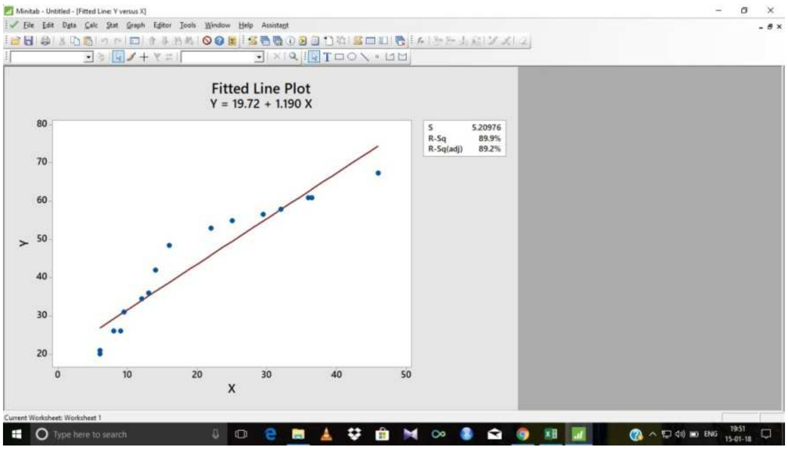

Figure 2: Graphical Representation of the Linear Regression Model Results

Applying Quadratic Regression Model, the equation for X & Y is established, the estimated values of Y and the related error values are analyzed, as shown in Table 3.

Table 3: Results of Quadratic Regression

X	Y	Y^ (Quadratric Model)	Error=Y-Y^
8	26	26.54204	-0.54204
6	20	22.00796	-2.00796
9.5	31	29.773865	1.226135
13	36	36.75234	-0.75234
16	48.5	42.10716	6.39284
6	21	22.00796	-1.00796
22	53	51.08124	1.91876
32	58	60.89564	-2.89564
9	26	28.71266	-2.71266
12	34.5	34.83884	-0.33884
25	55	54.7005	0.2995
29.5	56.6	59.044665	-2.444665
14	42	38.60156	3.39844
46	67.4	63.83676	3.56324
36	61	63.02156	-2.02156
36.5	61	63.214985	-2.214985
			-0.139735 (sum of the errors)

The quadratic regression equation is:

Y = 6.863+2.717X-0.03214X^2 (7)

Here, the model summary shows that value of R-sq is 97.2%, which means such percentage of variation of historical data is explained by the model. The total value of errors due to difference between collected values of Y & estimated values of Y is minimal, but higher than what is obtained from the first method, i.e. -0.139735, as explained in Figure 3.

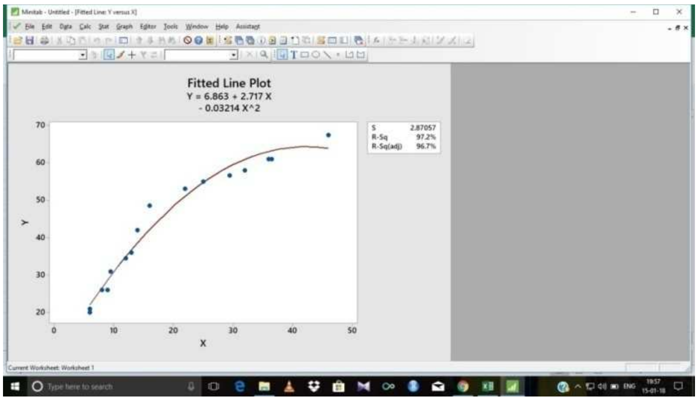

Figure 3: Graphical Representation of the Quadratic Regression Model Results

From Matrix method, no equation is formed. Here we get the values of estimated Y and as per the model summary, the total value of errors due to difference between collected values of Y & estimated values of Y is quite high, i.e. 85.84877122, as shown in Table 4.

Table 4: Results of Matrix Analysis

X	Y	Y^	Error=Y-Y^
8	26	15.25494	10.74505513
6	20	11.44121	8.558791349
9.5	31	18.11525	12.88475297
13	36	24.78929	11.21071459
16	48.5	30.50989	17.99011026
6	21	11.44121	9.558791349
22	53	41.9511	11.04890161
32	58	61.01978	-3.01977947
9	26	17.16181	8.838187023
12	34.5	22.88242	11.6175827
25	55	47.6717	7.328297287
29.5	56.6	56.25261	0.347390799
14	42	26.69615	15.30384648
46	67.4	87.71593	-20.315933
36	61	68.64725	-7.64725191
36.5	61	69.60069	-8.60068596
			85.84877122 (sum of the errors)

Inferences & Discussion

Comparing the results obtained from the above three methods, it is observed that the best result is obtained from Linear Regression Model, where the deviation of the estimated values of Y from its collected data, i.e. the total error value is least. Hence, this model is taken for further outcomes. Considering the core urban area / the parent city, X (distance) = 0 and Y = 19.72 (from equation no. 6), which is quite near of the value to total % of open space in the study area – Chandigarh (23% as per Chandigarh Master Plan 2031).

Further, considering the avg. distance of a peri-urban settlement from its core city in this study, X = 20.03 k.m. and Y = 43.6 % (from equation no. 7). A range of relation can be proposed in reference to the above.

- For Urban, open space = 20%, built space = 80% (obtained from the 1st case, where X=0)
- For Peri-Urban, open space = 44%, built space = 56% (obtained from the 2nd case, where X is considered an average value of 20 k.m.)
- For Rural, open space > 44%, built space < 56% (for the settlements in a distance beyond 20 k.m. from the core city)

Thus, a hierarchy of settlement structure is created using a common parameter like total % of open spaces. The same may be used for future master plans of cities to judge the saturation/capacity of the place, leading towards its categorization as 'urban' / 'peri-urban' / 'rural'.

CONCLUSIONS

In India, till date, the Census of India only defines 'Urban' area through 'Statutory Town' and 'Census Town' and rest of the settlements are considered as 'Rural' area. Even within this classification framework, Census Towns do not get Municipal status by State Governments and thus not being able to obtain facilities like other urban areas under Statutory Towns. In such classification, Peri-Urban areas are not at all captured. The only exception that we can find post- 2011, where 'Urban Agglomeration (UA)' has been coined by Census to identify the urban sprawl in the case of large metropolitan cities in India. However, UAs are not defined separately. The total population of 'Urban areas' along with its sprawl is counted to designate the UAs of Indian cities. From the outcome of the research proposal here, it is quite evident that there is an urgent need to identify / classify / delineate the Peri-Urban areas of Indian cities and thus a Third-Tier of development - 'Peri-Urban' needs to be included in the existing R-U Classification, defined by Census of India. The framework to delineate the Peri-Urban areas, as demonstrated in the research proposal for the case of Chandigarh; can be followed for all the big cities of the country and the same needs to be included in the planning process.

Till date, Census defines 'Urban' or 'Rural' area on the basis of the administrative status, population, density and occupational structure. However, from the research, it is inferred that these parameters have a lesser degree of association to predict the future peri-urban areas. Certain planning parameters are proposed here to be included in the definition of 'Urban' / 'Rural'. One of them is found truly relevant to delineate the future peri-urban areas, i.e. total % of open spaces. This can be even included as criteria of the definition of 'Urban', 'Rural' and 'Peri-Urban' areas. Other quantitative parameters may be explored further for better definition. By the inclusion of such planning parameters, the transition areas of development can be better captured explained in the future.

ACKNOWLEDGEMENTS

This paper, based on my ongoing Ph.D. Thesis would not have been complete without the unstinting help, support, guidance, and kindness of my Ph.D. thesis guide Dr. Madhumita Roy. I, first and foremost, thank her for encouraging myself to do a thorough research on such fundamental urban planning issue. I would also like to thank my family members, who have been a constant source of encouragement and inspiration during this research.

REFERENCES

1. *Shaw, A. (2005). Peri-urban interface of Indian cities - growth, governance and local initiatives. Economic and Political Weekly, Vol. 40, No. 2, pp. 129-136, Available online: http://www.jstor.org/stable/4416042, last visit: 14.05.2017.*
2. *Bhagat, R.B. (2005). Rural-urban classification and municipal governance in India. Singapore Journal of Tropical Geography, Vol. 26, Issue 1, pp. 61-73.Available online: http://onlinelibrary.wiley.com/doi/10.1111/j.01297619.2005.00204.x, last visit: 29.05.2017.*
3. *Saxena, M. & Sharma, S. (2015). Peri-urban area: A review of problems and resolution. International Journal of Engineering Research & Technology (IJERT), Vol. 4, Issue 09, pp. 15-18.*
4. *Budiyantini, Y. & Pratiwi, V. (2016). Peri-urban typology of Bandung Metropolitan Area. Procedia - Social and Behavioral Sciences, Vol. 227, pp. 833-837.*
5. *Saxena, Vijaylaxmi. "Locating Women's Crime In India's Social Structure: A Critical Perspective." International Journal of Research In Management & Social Science 5.3 (2017): 37.*
6. *Census of India (2001 & 2011). General population tables, Registrar General and Census Commissioner, GoI. Available online: Census of India/Rural-Urban Distribution.htm & http://censusindia.gov.in/ (accessed on 11.02.2017).*
7. *Firoz, M.C., Banerji, H. & Sen, J. (2014). A methodology to define the typology of rural urban continuum settlements in Kerala. Journal of Regional Development and Planning, Vol. 3, No. 1, pp. 49-60.*
8. *Goncalves, J., Gomes, M.C., Ezequiel, S., Moreira, F. & Ramos, I.L. (2017). Differentiating peri-urban areas: A transdisciplinary approach towards a typology. Land Use Policy, Vol. 63, pp. 331-341.*
9. *Batty, M. (1976). Urban Modelling - Algorithms, Calibrations, Predictions, 1st ed. London: Cambridge University Press.*
10. *Batty, M. (2009). Urban Modeling. In International Encyclopedia of Human Geography, 1st ed.; Thrift, N., Kitchin, R., Eds. Oxford: Elsevier.*
11. *Department of Urban Planning, UT Chandigarh, Chandigarh Administration (2016). Draft Chandigarh Master Plan – 2031 (unpublished). Available online: http://chandigarh.gov.in/cmp_2031.htm (accessed on 05.02.2016).*
12. *Directorate for public governance and territorial development (2011). OECD Regional Typology.*